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Southeast Coast Newfoundland Herring - 1985 Assessment

by

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Abstract

Data analysis for 1985 are presented for the two southeast coast Newfoundland herring stock complexes: 1) St. Mary's-Placentia Bays and 2) Fortune Bay. Landings from the commercial fishery, which was restricted to gillnets only, were less than 200 t. In St. Mary's-Placentia Bays the 11+ age group and the 1979 year-class were dominant in the commercial fishery. In Fortune Bay the fishery was dominated by the 1979, 1980, and 1982 year-classes. Samples from the acoustic purse seine survey in St. Mary's-Placentia Bays were dominated by the 1982 year-class; no samples were available from Fortune Bay. The research gillnet samples in St. Mary's-Placentia Bays were dominated by 11+ age groups followed by the 1982 and 1979 year-classes. In Fortune Bay research gillnet samples, the 1980 year-class was most abundant followed by the 1979 year-class and the 11+ age group. No catch rate data were available from the commercial fishery. Catch rates from the research gillnet program showed an increase from 1984 to 1985. Biomass estimates and population numbers at age were calculated from the acoustic purse seine surveys. Projections were made to 1987 assuming a fixed catch in 1986 and illustrative projections were made to 1992.

Résumé

Des analyses des données de 1985 sont présentées pour les deux complexes de stocks de harengs de la côte sud-ouest de Terre-Neuve: 1) baies St. Mary's et Placentia et 2) baie Fortune. Les débarquements de la pêche commerciale, limitée exclusivement au filet maillant, étaient inférieurs à 200 t. Dans les baies St-Mary's et Placentia le groupe d'âges 11+ et la classe d'âge de 1979 dominaient dans les captures commerciales. Dans la baie Fortune les classes d'âges de 1979, de 1980 et de 1982 dominaient. Les relevés au filet coulissant acoustique dans les baies St. Mary's et Placentia indiquent que la classe d'âge de 1982 domine; aucun échantillon provenant de la baie Fortune n'était disponible. Les échantillons prélevés au filet maillant dans les baies St. Mary's et Placentia étaient dominés par les groupes d'âges 11+ suivis des classes d'âge de 1982 et de 1979. Dans les échantillons recueillis au filet maillant dans la baie Fortune, la classe d'âge de 1980 était la plus abondante et elle était suivie de la classe d'âge de 1979 et du groupe d'âge 11+. Aucune donnée sur les taux de capture pour la pêche commerciale n'était disponible. Les taux de capture dans le cadre du programme de recherche au filet maillant indiquent un accroissement de 1984 à 1985. Les estimations de la biomasse et des populations en fonction de l'âge ont été calculées à partir des relevés au filet coulissant acoustique. On a établi des projections jusqu'en 1987 en supposant un taux de capture fixe en 1986 et des projections explicatives jusqu'en 1992.

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Introduction

A. Description of the Fishery:

In 1985, there was a spring and fall herring fishery in southeast Newfoundland which was restricted to gillnets only. The spring component allowed 400 t in St. Mary's-Placentia Bays and 200 t in Fortune Bay. It commenced April 1 and ended June 15. The fall fishery, which allowed 200 t in St. Mary's-Placentia Bays and 100 t in Fortune Bay, commenced October 1 and continued until December 31.

B. Nominal Catches:

TAC's and landings (x103 t) from the fishery are listed below for 1978-85.

		1978	1979	1980	1981	1982	1983	1984	1985
SMB-PB	TAC	4000	3400	2500	1200	0	0	0	600
	Nominal catch	3527	3617	2477	635	45	40	107	147[1]
FB	TAC	1000	1000	1000	200	0	0	0	300
	Nominal catch	999	1195	451	67	22	15	21	44[1]

[1]provisional

C. Anecdotal Information:

As in past assessments, the stock complexes considered are: 1) St. Mary's-Placentia Bays (3Lg and 3PSc) and 2) Fortune Bay (3PSn) (Fig. 1).

Annual average landings from the southeast coast herring stocks peaked around 30,000 t between 1945-50 and declined to an average of 3450 t from 1958 to 1962. Landings increased in 1968 to 21,900 t with the introduction of the purse seine fishery but have declined since then. Quota regulations were first placed on purse seiners in 1973 and on all other gear types in 1980. The purse seine fishery was closed in 1981; the ringnet fishery was closed in 1982. The bar seine fishery was closed in Fortune Bay in 1982 and in St. Mary's-Placentia Bays in 1983. The commercial gillnet fishery was closed from 1982-84 except for fixed gear bait permits and by-catches from the capelin and mackerel fishery. Landings, by gear, since quota regulation, are shown in Table 1 for St. Mary's-Placentia Bays and in Table 2 for Fortune Bay.

INPUT DATA

A. Biological Sampling:

The number of herring sampled in 1985, from the commercial fishery and research programs, was 3187 (Table 3). This ends a trend set in recent years

towards increased sampling with 19% fewer fish being sampled in 1985 than in 1984. However, when apportioned by stock area, month and gear type (Table 4), samples were available for 90% of the commercial catch. Samples were collected randomly and all fish sampled were measured and aged.

Mean weights at age (Table 5) for 1985 were derived from samples collected from January to June using both commercial and research samples.

B. Commercial Fishery Data:

Commercial catch-at-age data (Tables 6 and 7) were generated by applying age compositions from the appropriate commercial samples to landings. Where no commercial samples were available, catch-at-age data were generated using research samples collected from commercial mesh size (2 1/2-2 3/4") gillnets. As in past years, the catch matrix was derived for spring spawners only. The values for 1984 and 1985 are preliminary as final catch statistics were not available.

In St. Mary's-Placentia Bays the 11+ age groups were dominant followed by the 1979 year-class. This is similar to the catch structure in 1983 as opposed to 1984 when the 1979 year-class was dominant (Fig. 2). The proportion of fall spawners remained high (48.7%) particularly in the younger age groups. The 1982 year-class contributed only marginally (about 3%) to the commercial catch of spring spawners.

In Fortune Bay the age compositions in the commercial fishery were slightly different and for the first year since 1982 the 11+ age groups were not dominant (Fig. 2). The 1980 year-class was the most dominant, followed by the 1979 and 1982 year-classes. The overall proportion of fall spawners was approximately 40%. The 1982 year-class, predominated by spring spawners, contributed 33% to the 1985 fishery, a higher percentage than in any other Newfoundland stock area. This was the first year that the 1982 year-class was caught in the commercial fishery on any of the stocks.

No commercial catch rate data were available in 1985.

C. Research Survey Data:

i. Acoustic Purse Seine Survey:

In 1985, for the third consecutive year, an acoustic purse seine survey was carried out on the two stock complexes. The survey was conducted during March-April 1986 commencing in Fortune Bay and terminating in St. Mary's Bay. Two vessels were used, the research vessel MARINUS and a chartered commercial ringnet vessel. Survey design and data collection were similar to that described for the Newfoundland east coast survey (Wheeler et al. 1986). The cruise tracks and set locations for both vessels are shown in Appendices 1-7. During the survey 80 schools were measured (horizontal and vertical dimensions) over a cruise track of 2380 km during 560 vessel survey hours (Table 8).

There were nine purse seine sets during the survey, two in Fortune Bay, five in Placentia Bay, and none in St. Mary's Bay (Appendix 8). Only two sets were successful, both in Placentia Bay. In these sets, spring spawners predominated constituting about 74% of the catch. The 1982 year-class made up approximately 75% of the catch (Fig. 3) with the 1981 and 1979 year-classes being second and third in abundance in the catches.

Anchor tags were applied to 1000 herring (75% 1982 year-class) at each of the two successful set locations (Appendix 9) to further elucidate herring migratory patterns.

ii. Research Gillnet Program:

The research gillnet program, initiated in 1982, was continued for the fourth consecutive year on the southeast coast stocks during the spring of 1985 (April-May). Six southeast coast fishermen, each at the same location as in 1984, (Fig. 1) were contracted to fish a fleet of five gillnets (mesh sizes 2", 2 1/4", 2 1/2", 2 3/4", and 3"), maintain an accurate daily log record of catches, and to collect and freeze samples of their catch.

The age compositions of the research gillnet catches (Fig. 4 and Appendices 10-11) were calculated by applying age distributions of samples taken during the month, normally at four-day intervals, to catches during the interval and then combining these interval age distributions to obtain one for the entire month. The spawning type composition of these catches in St. Mary's-Placentia Bays was approximately 50% autumn and 50% spring spawners, similar to that of 1984. The 1982 year-class constituted less than 1% of total number of autumn spawners but 41% of the total number of spring spawners (Fig. 4). Overall, it was the dominant year-class, representing 22% of the catch. The second largest proportion of the catch was the 11+ age groups followed by the 1979 year-class.

In Fortune Bay, the 1980 year-class was most abundant followed by the 1979 year-class and the 11+ age group. Spring spawners constituted 73% of the research gillnet catch. The 1982 year-class represented less than 0.1% of the total number of autumn spawners and approximately 3% of the total catch of spring spawners. For the combined spawning groups, the 1982 year-class represented 2.3% of the catch by numbers.

As in previous years, two catch-per-unit-effort indices were calculated from the research gillnet program: 1) number of herring caught per fishing day and 2) number of herring caught per days hauled (Tables 9 and 10). The numbers in these tables vary slightly from those presented last year (Wheeler and Dalley 1985) due to recent computerization and standardization of technique of the time series for the different areas. Catch/days fished was higher in 1985 than in 1984 for two of the four locations in St. Mary's-Placentia Bays (Table 9) and approximately 12% higher for all four locations combined. In Fortune Bay, the catch/days fished was higher in both locations (Table 10). The catch rate in Fortune Bay was over three times higher in 1985 than in 1984.

D. Estimation of Parameters:

In determination of partial recruitment rates (Table 11) attempts were made to empirically assess the younger age groups, particularly the 1982 year-class. The population numbers at age, derived from the acoustic purse seine survey were compared with the commercial catch at age and the ratios that were derived were normalized to give partial recruitment patterns.

Instantaneous total mortality estimates (Paloheimo 1961) were calculated for ages 4+ for each of the research gillnet catch rate series (Tables 12-13). Age 4+ was chosen after examination of the catch-at-age data from the research gillnet program (Appendices 10-11) and the mesh selectivity of the various sized nets. From these data it appeared that full recruitment to the research gillnets occurred at age 4+. It was impossible to discern any trends in Z value due to the variability within the data.

ASSESSMENT RESULTS

A. Biomass Calculation from Acoustic Survey:

The survey was designed such that each of the two vessels covered a separate cruise track, primarily within the 90 m contour. Only those times when the vessel was actively searching were included in estimating the length of the cruise track. Accurate records of vessel speed were kept for this purpose. The cruise track width was estimated as the lateral distance swept by the sonar while searching (0.304 km). It was therefore possible to estimate the square area surveyed (km^2) within each stock area.

The vessel used its sonar to locate schools within the cruise track. Single line transects of each school would then be marked on the sounder paper. Horizontal and vertical dimensions of each school were subsequently measured. School depth was measured directly from the sounder scale; the horizontal dimension was converted from "mm" on the sounder to meters by relating sounder paper speed (sec/mm) to vessel speed (m/sec). The number of schools recorded on the sounder was considered to be a conservative estimate as not all schools observed by sonar within the cruise track were recorded on the sounder.

During the 1984 acoustic purse seine survey, and again in 1985, a relationship was calculated (Fig. 5) between cross-sectional area of schools (m^2) and weight per school (kg) as visually estimated from purse seine sets in shallow water (<30 m) where it was considered that the entire school had been caught. The relationship between school area and school size was applied to each of the schools measured during the survey to obtain an estimate of tons observed within each bay (Table 14). Tons per km^2 surveyed were then calculated. These density estimates were prorated by areal expansion to give biomass estimates within the 90 m contour, considered to be the extent of stock range. Since a number of schools were observed outside the 90 m contour, these biomass estimates were considered to be conservative.

Prior to the acoustic survey, each stock area was divided into smaller subareas or grids (Fig. 6). The observed biomass was calculated for each of these grids. Ideally, a biomass estimate within the 90 m contour should be calculated for each of these grids and then these individual estimates combined to determine stock biomass. However, an accurate estimation of stock area in each grid has not yet been calculated and therefore the biomass has not been apportioned.

In calculating numbers at age, the results from the 1985 acoustic survey in Fortune Bay were analyzed and estimates were weighted by the observed biomass within each of the sampled grids (Table 15). The observed biomass was apportioned into spring and autumn spawning components based on percentages within the purse seine samples. The observed biomass was converted to numbers by applying the mean sample weight. The total observed numbers were apportioned into numbers at age by the age composition of the sample. The observed numbers at age within each grid were combined and adjusted to include those grids in which no samples were taken. This provided predicted numbers at age within the cruise track which in turn were adjusted to give stock numbers at age within the 90 m contour. This was not done in 1986 as no samples were collected during the purse seine survey in Fortune Bay. Similarly, no samples were collected in St. Mary's-Placentia Bays in 1985. In 1986, samples were collected from one grid only in St. Mary's-Placentia Bays and age compositions from these samples were converted to stock numbers at age for all grids combined (Table 16). Population numbers at age for both stock areas, 1985 and 1986, are summarized in Table 17.

As no samples were available for Fortune Bay from the 1986 surveys, the 1985 population age structure was projected ahead one year and applied to the 1986 biomass estimate. For Fortune Bay, the mean of the estimates of the 1982 year-class from the 1985 and 1986 surveys was used as a minimum estimate of the population size for projections. Similarly, the estimate of the 1982 year-class from the 1986 survey in St. Mary's-Placentia Bays was used to project to 1987.

There are several sources of uncertainty in the calculation of stock biomass from the purse seine surveys which may produce either negative or positive biases in the results. These will have to be examined in more detail prior to the next assessment.

The relationship between cross-sectional areas of schools and weight per school assumes that the single line transect is through the widest lateral dimension of the school and that there is symetry to the school. For larger schools, it is difficult to ensure that the school is crossed on its widest axis. The impact of this when determining the relationship is uncertain; however, the relationship (Fig. 5), as derived, suggests that the weight of larger schools may be underestimated.

The cruise track width may be underestimated as schools which are detected and measured at the outermost lateral edge of the track would increase the effective width of the search pattern. The effect of changing vessel course to measure these schools is uncertain, as schools on the original course may be undetected.

It is also difficult to determine the effect of calculating population age compositions using the overall stock area estimate rather than from a summation of grid biomasses as the effect depends on whether there are different densities of herring in larger or smaller grids.

B. Cohort Analysis:

Cohort analysis was not conducted for these stocks because reliable estimates of partial recruitment values and terminal fishing mortality could not be calculated.

PROGNOSIS

A. Catch Projections:

The population numbers for the 1982 year-class calculated from the acoustic purse seine survey were used to project 1987 numbers assuming a catch in 1986 of 2100 t in St. Mary's-Placentia Bays and 700 t in Fortune Bay. These catches were assumed reasonable as they form the basis of the 1986 Herring Management Plan and may represent maximum catches due to poor market conditions. The population numbers used to initiate the projections in 1986 were corrected for natural mortality from the time of the acoustic survey to the beginning of 1986. Mean weights at age were from samples collected in 1985 (Table 5). Natural mortality was assumed to be 0.20 and $F_{0.1}$ to be 0.30. Recruitment at age 2 was assumed to be zero. The following partial recruitment pattern, based upon a historical combined purse seine and gillnet fishery (Winters and Moores 1977), was used in the projection.

Age	2	3	4	5+
PR	0.10	0.35	0.60	1.00

The results of the projections are as follows:

	St. Mary's-Placentia Bays	Fortune Bay
2+ Biomass (t)	10,746	10,149
Catch (t)	2,550	2,400

Illustrative projections have been made to 1992 to show the effect of reduced fishing mortality (F = 0.20) and constant annual catches. The same population numbers, mean weight at age, recruitment values and partial recruitment pattern as described above were used. Since these herring stocks are near the northern end of their range, stock recruitment tends to be sporadic, 14 years between the 1968 and 1982 year-classes. To help compensate for this sporadic recruitment, projections have been made assuming two levels of fishing mortality, F = 0.30 and F = 0.20. Projections have also been made to illustrate the effect of implementing different arbitrary annual catch levels.

The results for St. Mary's-Placentia Bays are as follows:

	F = 0.30		F = 0.20		C = 1000 t		C = 2000 t	
Year	5+biomass	Catch	5+biomass	Catch	5+biomass	F_{5+}	5+biomass	F_{5+}
1987	10,700	2,600	10,700	1,800	10,700	0.11	10,700	0.23
1988	7,600	1,800	8,400	1,400	9,020	0.13	8,200	0.31
1989	5,200	1,200	6,300	1,000	7,500	0.16	5,500	0.51
1990	3,300	800	4,500	700	5,500	0.22	2,850	1.42
1991	2,100	500	3,100	500	3,800	0.35	-	
1992	1,400	300	2,300	400	2,400	0.60	-	

The results for Fortune Bay are as follows:

	F = 0.30		F = 0.20		C = 1000 t		C = 2000 t	
Year	5+biomass	Catch	5+biomass	Catch	5+biomass	F_{5+}	5+biomass	F_{5+}
1987	10,100	2,400	10,100	1,700	10,100	0.18	10,100	0.12
1988	7,000	1,700	7,800	1,300	8,000	0.23	8,500	0.14
1989	4,700	1,100	5,800	900	5,700	0.34	6,700	0.18
1990	3,300	800	4,500	700	3,900	0.55	5,300	0.23
1991	2,000	500	3,000	500	1,800	2.05	3,500	0.38
1992	1,300	300	2,100	300	-	-	2,000	0.77

B. Management Implications:

Similar to last year, projections have been based entirely upon population estimates derived from the acoustic survey. This technique shows excellent potential as it is independent of the commercial fishery and provides estimates of year-class size prior to their recruitment to the fishery. Although refinements have been made from last year, the estimates are still very preliminary and further analysis is required, in particular with regard to the relationship between school size and school weight and other sources of uncertainty. A comparative survey, involving more sophisticated hydroacoustic techniques to estimate school size and density, would provide more information on this relationship.

The short term future of the Newfoundland herring stocks looks secure with the recruitment of the 1982 year-class. The long term future depends both upon management practices and recruitment success.

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Table 1. St. Mary's-Placentia Bays herring landings (t), by gear, 1973-85. (SMB = St. Mary's Bay; PB = Placentia Bay)

Year	Area	Gear					
		Purse seine	Ringnet	Bar seine	Gillnet	Trap	Total
1973	S.M.B.	734	-	97	95	10	936
	P.B.	4557	-	-	699	39	5295
	Combined	5291	-	97	794	49	6231
1974	S.M.B.	1710	51	271	470	37	2539
	P.B.	3200	-	212	510	11	3933
	Combined	4910	51	483	980	48	6472
1975	S.M.B.	1032	711	554	674	243	3214
	P.B.	2638	-	225	450	188	3501
	Combined	3670	711	779	1124	431	6715
1976	S.M.B.	-	920	158	352	25	1455
	P.B.	2056	172	242	177	-	2647
	Combined	2056	1092	400	529	25	4102
1977	S.M.B.	-	1131	221	531	29	1912
	P.B.	740	524	14	78	-	1356
	Combined	740	1655	235	609	29	3268
1978	S.M.B.	-	1523	66	490	3	2082
	P.B.	557	612	29	214	33	1445
	Combined	557	2135	95	704	36	3527
1979	S.M.B.	-	1570	131	332	9	2042
	P.B.	359	891	17	307	1	1575
	Combined	359	2461	148	639	10	3617
1980	S.M.B.	-	645	16	352	12	1025
	P.B.	182	892	9	339	30	1452
	Combined	182	1537	25	691	42	2477
1981	S.M.B.	-	44	8	122	-	174
	P.B.	-	311	-	149	1	461
	Combined	-	355	8	271	1	635
1982	S.M.B.	-	-	-	10	-	10
	P.B.	-	-	4	31	-	35
	Combined	-	-	4	41	-	45
1983	S.M.B.	-	-	-	13	-	13
	P.B.	-	-	-	27	-	27
	Combined	-	-	-	40	-	40
1984*	S.M.B.	-	-	-	11	-	11
	P.B.	-	-	1	94	-	95
	Combined	-	-	1	105	-	106
1985*	S.M.B.	-	-	-	31	-	31
	P.B.	3	-	-	113	-	116
	Combined	3	-	-	144	-	147

* provisional

Table 2. Fortune Bay herring landings (t), by gear, 1973-85.

Year	Gear				Total
	Purse seine	Bar seine	Gillnet	Trap	
1973	2053	1117	83	1	3254
1974	1928	268	72	-	2268
1975	809	81	19	-	909
1976	109	310	43	-	462
1977	188	364	22	5	579
1978	104	854	41	-	999
1979	285	829	81	-	1195
1980	97	265	89	-	451
1981	-	30	37	-	67
1982	-	-	20	2	22
1983	-	-	15	-	15
1984*	-	-	21	-	21
1985*	-	-	44	-	44

* provisional

Table 3. Number of fish sampled from the southeast Newfoundland herring fishery, by area and gear, 1980-85 (research samples in parentheses). (SMB = St. Mary's Bay, PB = Placentia Bay, FB = Fortune Bay)

Year	Area	Gear type				Total # sampled	Comm. catch (t)
		Trap	Bar seine	Gillnet	Ringnet		
1980	SMB	-	-	-	250	250	1025
	PB	-	-	(50)	2189	2189 (50)	1452
	FB	-	250	100	200	550	451
	Total	-	250	100 (50)	2639	2989 (50)	2928
1981	SMB	-	-	400 (18)	669	1069 (18)	174
	PB	-	-	-	300	300	461
	FB	-	-	(34)	-	(34)	67
	Total	-	-	400 (52)	969	1369 (52)	702
1982	SMB	-	-	1196 (439)	-	1196 (439)	10
	PB	-	-	(428)	-	(428)	35
	FB	-	-	(273)	-	(273)	22
	Total	-	-	1196(1140)	-	1196(1140)	67
1983	SMB	-	-	(659)	798	798 (659)	12
	PB	100	-	(605)	-	100 (605)	27
	FB	-	-	(1017)	-	(1017)	15
	Total	100	-	(2281)	798	898(2281)	54
1984	SMB	-	-	(1110)	223	223(1110)	11
	PB	98	-	488 (653)	(136)	586 (789)	95
	FB	-	-	466 (612)	(182)	466 (794)	21
	Total	98	-	954(2375)	223 (318)	1275(2693)	127
1985	SMB	-	-	50 (598)	50	100 (598)	31
	PB	-	-	92 (697)	50	142 (697)	116
	FB	-	-	500 (900)	(250)	500(1150)	44
	Total	-	-	642(2195)	100 (250)	742(2445)	191

Table 4. Commercial catch (t) and sampling (number of fish) for 1985, by stock area, month and gear type.

		SMB-PB		FB	
Month	Gear	Catch (t)	No. sampled	Catch (t)	No. sampled
January	Gillnet	-	-	1	-
March	Gillnet	-	-	2	-
April	Gillnet	34	211	17	335
May	Gillnet	45	371	11	312
June	Gillnet	57	83	8	100
August	Gillnet	1	-	1	-
September	Gillnet	2	-	3	-
October	Gillnet	2	-	-	-
	Purse seine	3	-	-	-
November	Gillnet	2	-	-	-
December	Gillnet	1	-	1	-
Combined	Gillnet	144	665	44	747
	Purse seine	3	-	-	-

Table 5. Mean weight at age (g) of southeast coast Newfoundland herring from samples collected January-June, 1985. Sample sizes in parentheses.

Age	Stock area	
	St. Mary's-Placentia Bays	Fortune Bay
2	-	-
3	133 (259)	147 (237)
4	211 (23)	202 (7)
5	241 (86)	251 (339)
6	282 (52)	287 (115)
7	316 (22)	317 (25)
8	332 (10)	368 (11)
9	348 (36)	373 (18)
10	386 (9)	387 (9)
11+	411 (246)	439 (204)

Table 6. Commercial catch at age for St. Mary's-Placentia Bays, 1966-85.

Age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
2	1	1	3232	1	476	1	1	77	996	74
3	1066	1	439	629	109	557	207	326	281	2234
4	104	2362	29	54	4434	116	20375	77	233	472
5	114	158	7417	53	59	2112	725	15470	127	172
6	164	302	399	861	76	80	5154	593	14329	1625
7	1912	788	679	67	645	44	366	6760	436	13857
8	1282	1451	953	55	67	252	100	95	6049	146
9	137	407	2836	99	72	13	900	33	138	3391
10	43	85	2577	347	37	22	73	285	57	351
11	993	33	359	143	38	24	76	60	400	100
12	1	754	139	20	22	25	83	62	67	600
13	1	1	3182	8	3	15	86	68	70	103
14	1	1	1	177	1	2	52	70	76	107
15	1	1	1	1	27	1	7	42	79	117
16	1	1	1	1	1	18	3	6	47	121
17	1	1	1	1	1	1	62	2	7	72
18	1	1	1	1	1	1	1	51	2	11
19	1	1	1	1	1	1	1	1	57	3
20	1	1	1	1	1	1	1	1	1	87

Age	1976	1977	1978	1979	1980	1981	1982	1983	1984*	1985*
2	365	52	30	88	133	1	1	1	8	1
3	391	1423	175	663	331	193	1	5	9	7
4	1905	140	1817	279	133	42	2	2	24	18
5	208	736	123	2264	153	111	3	3	35	27
6	267	87	597	97	1269	51	8	2	6	21
7	863	50	64	614	57	338	3	4	3	15
8	5622	1039	106	86	470	28	14	1	23	3
9	201	3830	512	66	38	80	4	9	1	25
10	2256	134	3827	502	238	6	4	1	10	5
11	286	1526	113	3046	265	37	1	2	1	23
12	70	194	1291	90	1609	41	5	1	2	2
13	500	36	164	1028	48	247	6	3	1	5
14	84	350	27	131	543	7	36	3	3	2
15	87	57	300	30	69	84	1	19	3	7
16	95	58	48	230	18	11	12	1	21	7
17	98	65	50	38	120	11	2	6	1	49
18	59	66	54	40	20	19	2	1	7	2
19	9	40	56	43	21	2	1	1	1	16
20	73	55	80	108	80	3	3	2	3	9

* preliminary

Table 7. Commercial catch at age for Fortune Bay, 1966-85.

Age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
2	1	1	6549	515	42383	174	1536	2220	389	2
3	223	89	128	11984	7997	24094	260	924	1333	279
4	13	24764	317	85	10433	6314	19975	67	543	582
5	22	46	48563	187	87	24357	2941	5671	121	112
6	90	49	216	13038	189	1210	10937	454	4574	87
7	66	422	124	188	7312	270	357	1749	117	1490
8	90	450	610	261	241	9314	4458	78	1119	16
9	28	513	770	690	16	137	1054	240	9	142
10	2	358	920	1935	234	153	35	598	117	22
11	17	15	617	884	141	261	80	15	199	63
12	1	123	26	593	64	157	137	34	5	107
13	1	1	212	25	43	71	82	58	11	3
14	1	1	1	204	2	48	37	35	19	6
15	1	1	1	1	15	2	25	16	12	10
16	1	1	1	1	1	17	1	11	5	6
17	1	1	1	1	1	1	9	1	4	3
18	1	1	1	1	1	1	1	4	1	2
19	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1

Age	1976	1977	1978	1979	1980	1981	1982	1983	1984*	1985*
2	82	28	1	1	25	1	1	1	4	1
3	15	2114	42	1	16	144	1	5	1	34
4	318	25	2705	183	3	16	3	2	10	1
5	228	328	63	3811	69	4	3	3	5	37
6	129	166	240	15	1122	3	1	2	4	11
7	11	26	44	165	7	21	2	4	1	2
8	337	44	141	5	183	2	36	1	2	1
9	36	189	52	24	1	23	1	9	1	1
10	187	4	330	1	11	1	5	1	2	1
11	14	140	5	87	1	2	1	6	2	1
12	40	10	172	1	26	1	1	1	12	1
13	67	30	12	45	1	5	1	1	2	1
14	2	50	37	3	13	1	2	1	2	4
15	4	1	61	10	1	3	1	2	2	1
16	6	3	1	16	3	1	1	1	4	1
17	4	4	4	1	5	1	1	1	2	1
18	2	3	5	1	1	1	1	1	2	1
19	1	1	4	1	1	1	1	1	2	1
20	1	1	2	2	1	1	1	2	6	3

* preliminary

Table 8. Southeast coast Newfoundland acoustic purse seine survey parameters and abundance indices, 1985-86.

Area	Year	Schools observed	Tons observed	km	hrs	t/km	t/hr
FB	1985	72	9936	419.5	75.3	23.7	132.0
	1986	44	9603	676.0	82.5	14.2	116.4
PB	1985	?	?	950.5	109.6	?	?
	1986	33	3476	1411.2	167.9	2.5	20.7
SMB	1985	0	0	288.9	27.0	0.0	0.0
	1986	3	3	290.8	29.7	<0.1	0.1

Table 9. Total catch (number of fish), number of days fished, number of days hauled, and catch rates for the research gillnet program, St. Mary's Bay-Placentia Bay.

Area	Community	Year	Total catch	Days fished	Days hauled	Catch/ days fished	Catch/ days hauled
SMB	Riverhead	1982	680	25	21	27	32
		1983	962	31	24	31	41
		1984	2960	46	37	64	80
		1985	6108	32	25	191	244
	Colinet	1982	71	31	26	2	3
		1983	3193	37	30	86	106
		1984	3270	31	25	105	131
		1985	637	34	28	19	23
PB	Long Harbour	1982	663	32	18	21	37
		1983	3142	29	18	108	175
		1984	27357	32	16	855	1710
		1985	20823	32	17	651	1225
	Swift Current	1982	491	31	20	16	25
		1983	1873	31	23	60	81
		1984	818	31	17	26	48
		1985	8267	32	19	258	435
SMB-PB	Combined	1982	1905	119	85	16	22
		1983	9170	128	95	72	97
		1984	34405	140	95	246	362
		1985	35835	130	89	276	403

Table 10. Total catch (number of fish), number of days fished, number of days hauled, and catch rates for the research gillnet program, Fortune Bay.

Area	Community	Year	Total catch	Days fished	Days hauled	Catch/ days fished	Catch/ days hauled
FB	Long Harbour	1982	53	33	24	2	2
		1983	9711	29	23	335	422
		1984	5806	32	23	181	257
		1985	9016	34	21	265	429
	Belle Bay	1982	746	32	25	23	30
		1983	942	31	25	30	38
		1984	5908	26	14	227	422
		1985	29285	26	16	1118	1786
FB	Combined	1982	799	65	49	12	16
		1983	10653	60	48	178	222
		1984	11714	58	37	202	320
		1985	38301	60	37	636	1024

Table 11. Calculation of partial recruitment pattern from acoustic purse seine population numbers at age and commercial catch at age.

	Age	Commercial catch ($x10^3$)	Population numbers ($x10^6$)	C/N	Partial recruitment calculated	Partial recruitment used
St. Mary's Bay- Placentia Bay	2	-	-	-	-	0.0010
	3	6.9	186.6	.000037	.006343	0.0063
	4	17.7	21.8	.000812	.139208	0.1400
	5	27.1	9.7	.002794	.478999	0.4800
	6	21.0	3.6	.005833	1.000000	1.0000
	7	14.8	-	-	-	0.9700
	8	3.3	-	-	-	0.9100
	9	24.5	-	-	-	0.8500
	10	4.8	-	-	-	0.7800
	11+	124.3	-	-	-	0.7100
Fortune Bay	2	-	-	-	-	0.0010
	3	33.9	170.2	.000199	.082197	0.0822
	4	1.3	0.9	.001444	.596448	0.6000
	5	36.8	15.2	.002421	1.000000	1.0000
	6	11.2	6.3	.001778	.734315	1.0000
	7	1.8	-	-	-	0.9700
	8	1.1	-	-	-	0.9100
	9	1.3	-	-	-	0.8500
	10	0.4	-	-	-	0.7800
	11+	14.7	-	-	-	0.7100

Table 12. Calculation of instantaneous total mortality (Z) from research gillnet program where F is number of days fished.

		Z4+			
Area	Community	1982-83	1983-84	1984-85	1983-85
St. Mary's Bay- Placentia Bay	Riverhead	0.02	0.21	-1.10	-1.32
	Collnet	-4.00	-0.20	2.92	3.18
	Long Harbour	-0.79	-2.07	0.46	-1.76
	Swift Current	-0.78	0.66	0.81	-0.14
	Combined	-0.95	-0.85	0.21	-0.76
Fortune Bay	Long Harbour	-5.25	0.54	0.20	0.47
	Belle Bay	-0.25	-1.40	-1.77	-2.66
	Combined	-2.47	0.02	-1.17	-0.69

Table 13. Calculation of instantaneous total mortality (Z) from research gillnet program where F is number of days hauled.

Area	Community	Z4+ 1982-83	1983-84	1984-85	1983-85
St. Mary's Bay-Placentia Bay	Riverhead	-0.06	0.25	-1.13	-1.31
	Colinet	-4.03	-0.21	2.94	3.19
	Long Harbour	-0.69	-2.28	0.52	-1.91
	Swift Current	-0.64	0.35	-0.73	-0.36
	Combined	-0.97	-0.89	0.22	-0.79
Fortune Bay	Long Harbour	-5.15	0.44	-0.35	0.22
	Belle Bay	-0.21	-1.80	-1.63	-2.93
	Combined	-2.41	-0.21	-1.21	-0.95

Table 14. Calculation of herring biomass from acoustic purse seine surveys, 1985-86 for Fortune Bay, Placentia Bay, and St. Mary's Bay.

	Area	Grid	Tons observed	Km^2 surveyed	t/km^2	Area grid	Within (km^2)	Biomass (t)
1985	FB	31	0	0.0	0.0		540	-
		32	4726	51.5	91.8		300	27530
		33	5154	56.9	90.6		360	32609
		34	56	19.2	2.9		600	1750
			9936	127.6			1800	61889
1986	FB	31	0	0.0	0.0		540	-
		32	9242	65.9	140.2		300	42073
		33	57	85.0	0.7		360	241
		34	304	54.6	5.6		600	3341
			9603	205.5			1800	45655
	PB	26	12	36.6	0.3		1250	410
		27	2800	46.7	60.0		750	44968
		28	29	175.7	0.2		600	99
		29	15	147.5	0.1		1400	142
		30	620	22.5	27.6		1150	31689
			3476	429.0			5150	77308
	SMB	24	0	0.0	0.0		700	-
		25	3	88.4	0.1		1650	56
			3	88.4			2350	56

Table 15. Numbers at age within sampled grids from the 1985 acoustic purse seine survey converted to stock numbers for Fortune Bay.

Grid	Total biomass	From samples SS	From samples AS	Total biomass SS	Total biomass AS	Mean sample wgt. (kg)	Total nos. ($\times 10^6$) SS	Total nos. ($\times 10^6$) AS
32	27530	87.0%	13.0%	23951	3579	0.174	137.65	20.57
33	32609	92.0%	8.0%	30000	2609	0.158	189.88	16.51
34	1750	-	-	-	-	-	-	-
32-34	61889							

Spring spawners

Age	Grid 32 No. sampled	Grid 32 %	Grid 32 Total numbers ($\times 10^6$)	Grid 33 No. sampled	Grid 33 %	Grid 33 Total numbers ($\times 10^6$)	32 & 33 Total numbers ($\times 10^6$)	Stock numbers ($\times 10^6$)	%
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	136	78.2	107.64	43	93.5	177.54	285.18	293.48	78.2
4	2	1.1	1.51	-	-	-	1.51	1.55	0.4
5	22	12.6	17.34	2	4.3	8.16	25.50	26.54	7.0
6	8	4.6	6.33	1	2.2	4.18	10.51	10.82	2.9
7	-	-	-	-	-	-	-	-	-
8	1	0.6	0.83	-	-	-	0.83	0.85	0.2
9	1	0.6	0.83	-	-	-	0.83	0.85	0.2
10	1	0.6	0.83	-	-	-	0.83	0.85	0.2
11+	3	1.7	2.34	-	-	-	2.34	2.41	0.6
TOTAL	174	100.0	137.65	46	100.0	189.99	327.53	337.05	89.8

Autumn spawners

Age	Grid 32 No. sampled	Grid 32 %	Grid 32 Total numbers ($\times 10^6$)	Grid 33 No. sampled	Grid 33 %	Grid 33 Total numbers ($\times 10^6$)	32 & 33 Total numbers ($\times 10^6$)	Stock numbers ($\times 10^6$)	%
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	11	42.4	8.72	-	-	-	8.72	8.97	2.4
4	4	15.4	3.17	2	50.0	8.26	11.43	11.76	3.1
5	3	11.5	2.37	-	-	-	2.37	2.44	0.7
6	5	19.3	3.97	2	50.0	8.26	12.23	12.59	3.4
7	1	3.8	0.78	-	-	-	0.78	0.80	0.2
8	1	3.8	0.78	-	-	-	0.78	0.80	0.2
9	1	3.8	0.78	-	-	-	0.78	0.80	0.2
10	-	-	-	-	-	-	-	-	-
11+	-	-	-	-	-	-	-	-	-
TOTAL	26	100.0	20.57	4	100.0	16.52	37.08	38.16	10.2

Table 16. Age compositions of biological samples from the 1986 acoustic purse seine survey converted to stock numbers at age for St. Mary's-Placentia Bay.

	Total biomass	From samples SS	From samples AS	Total biomass (t) SS	Total biomass (t) AS	Mean sample wgt. (kg)	Total nos. ($x10^6$) SS	Total nos. ($x10^6$) AS
SMB-PB	77364	74.4%	25.6%	55559	19805	0.261	212.87	75.88

	Spring spawners			Autumn spawners		
Age	Number sampled	%	Stock numbers	Number sampled	%	Stock numbers
0	-	-	-	-	-	-
1	-	-	-	-	-	-
2	1	0.5	1.06	-	-	-
3	-	-	-	-	-	-
4	155	83.4	177.53	34	53.1	40.29
5	18	9.7	20.65	7	10.9	8.27
6	8	4.3	9.15	2	3.1	2.35
7	3	1.6	3.41	17	26.6	20.18
8	-	-	-	1	1.6	1.21
9	-	-	-	2	3.1	2.35
10	-	-	-	-	-	-
11+	1	0.5	1.06	1	1.6	1.21
TOTAL	186	100.0	212.86	64	100.0	75.86

Table 17. Stock numbers at age and biomass estimates derived from acoustic purse seine surveys, 1985-86, for Fortune Bay (FB) and St. Mary's Bay-Placentia Bay (SMB-PB).

		Numbers at age ($x10^6$)			
		1985		1986	
Area	Age	Autumn spawners	Spring spawners	Autumn spawners	Spring spawners
FB	0	-	-	-	-
	1	-	-	-	-
	2	-	-	-	-
	3	9.0	293.5	-	-
	4	11.8	1.6	-	-
	5	2.4	26.2	-	-
	6	12.6	10.8	-	-
	7	0.8	-	-	-
	8	0.8	0.9	-	-
	9	0.8	0.9	-	-
	10	-	0.9	-	-
	11+	-	2.4	-	-
Total nos.		38.2	337.1	-	-
Biomass (t)		6289	55590	-	-
SMB-PB	0	-	-	-	-
	1	-	-	-	-
	2	-	-	-	1.1
	3	-	-	-	-
	4	-	-	40.3	77.5
	5	-	-	8.3	20.7
	6	-	-	2.4	9.2
	7	-	-	20.2	3.4
	8	-	-	1.2	-
	9	-	-	2.4	-
	10	-	-	-	-
	11+	-	-	1.2	1.1
Total nos.		-	-	75.9	212.9
Biomass (t)		-	-	19805	55559

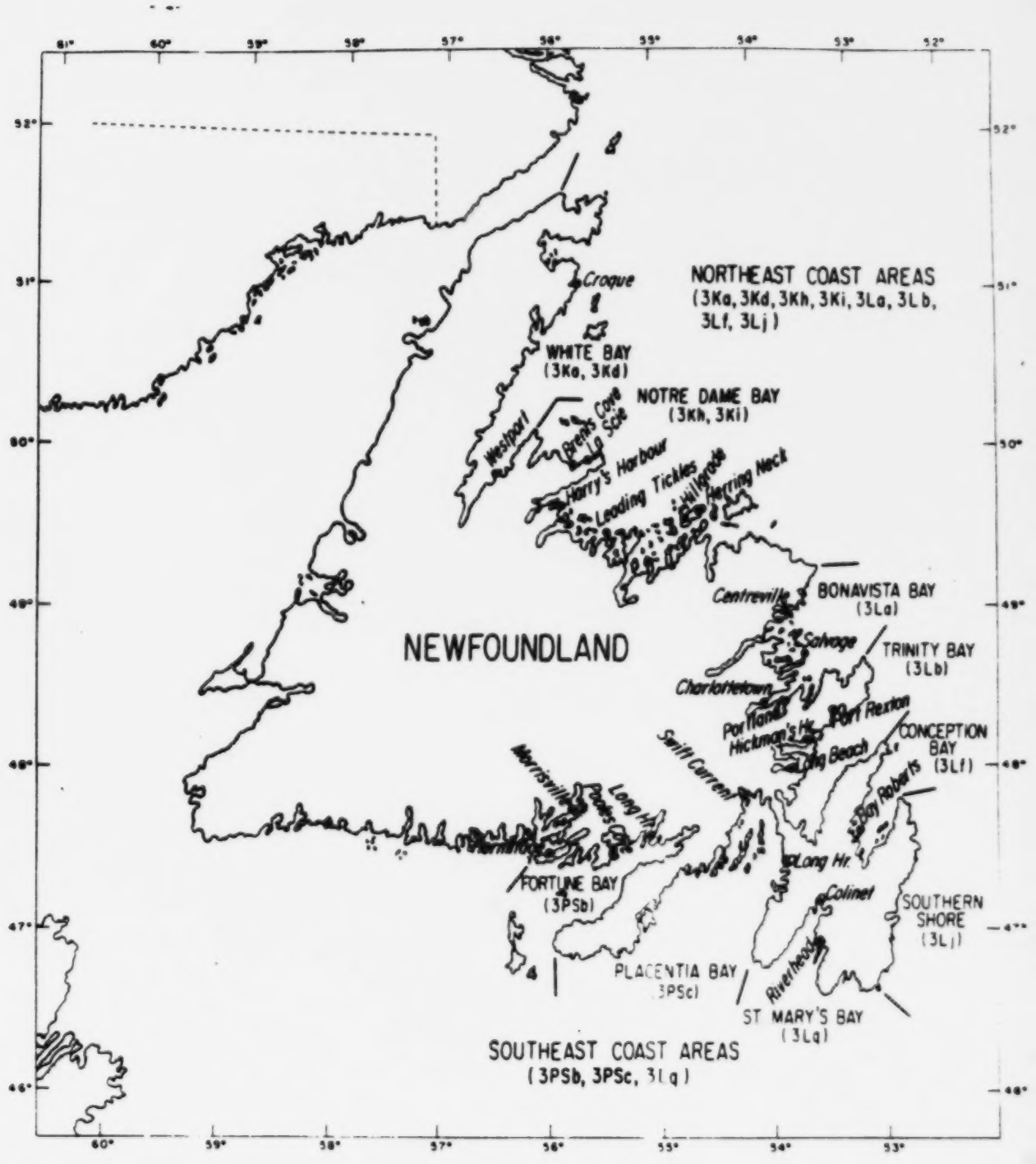


Fig. 1. Area map indicating herring stock complexes and research gillnet community locations.

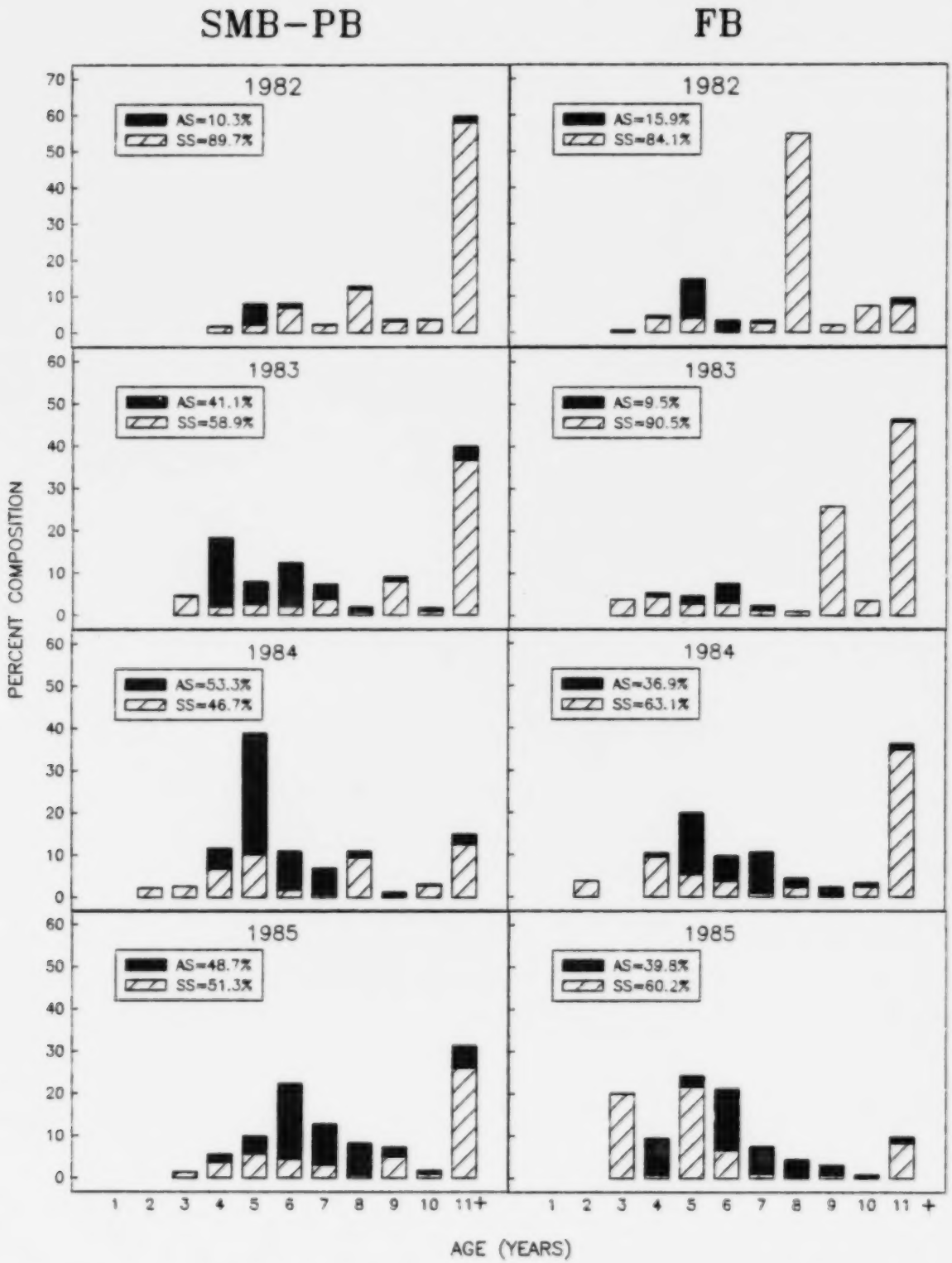


Fig.2. Age composition of herring from commercial fishery, St. Mary's Bay – Placentia Bay (SMB–PB), and Fortune Bay (FB), 1982–85.

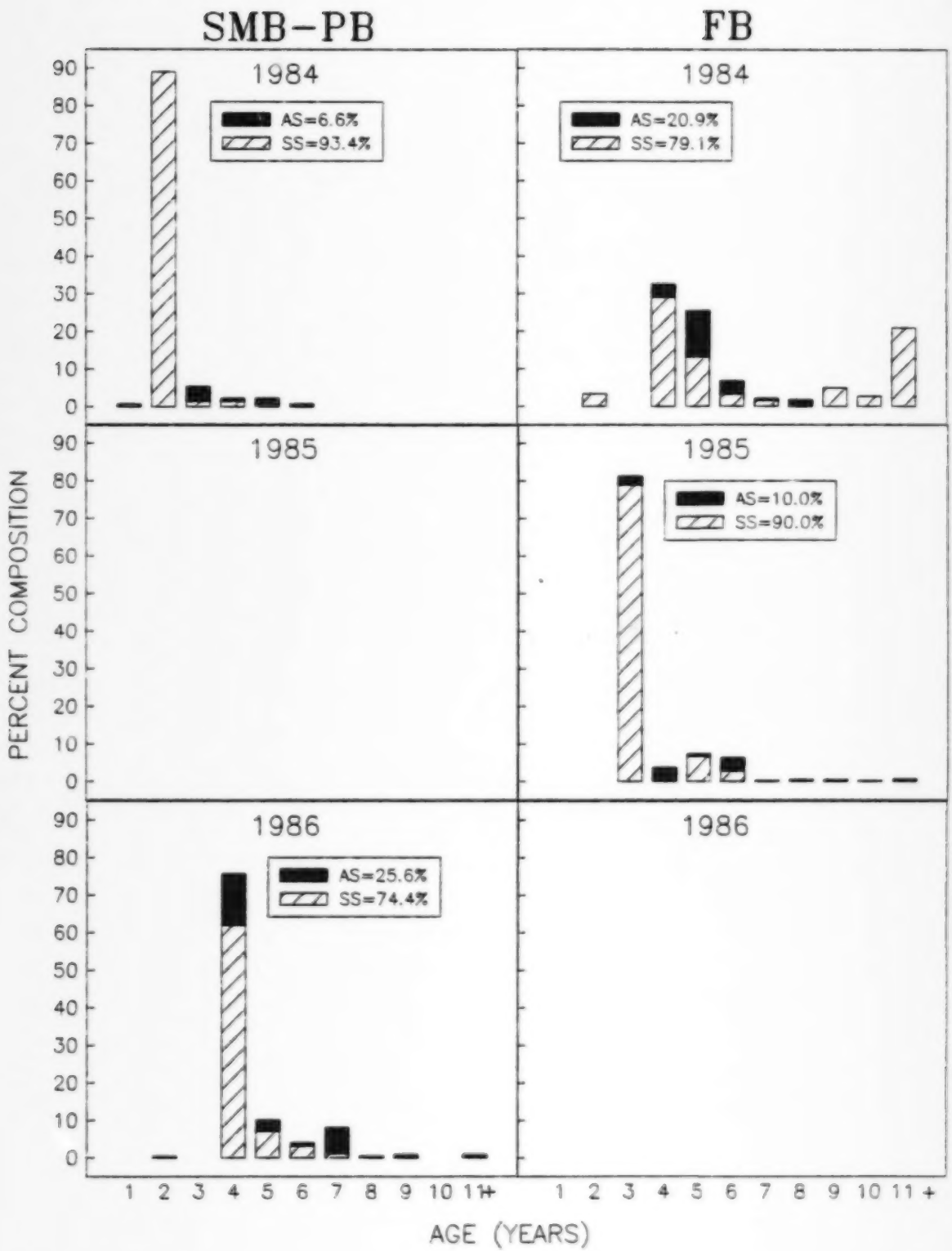


Fig.3. Stock age composition of herring from acoustic purse seine surveys, St. Mary's – Placentia Bay, and Fortune Bay, 1984–86. (1984 age compositions are from unadjusted samples only.)

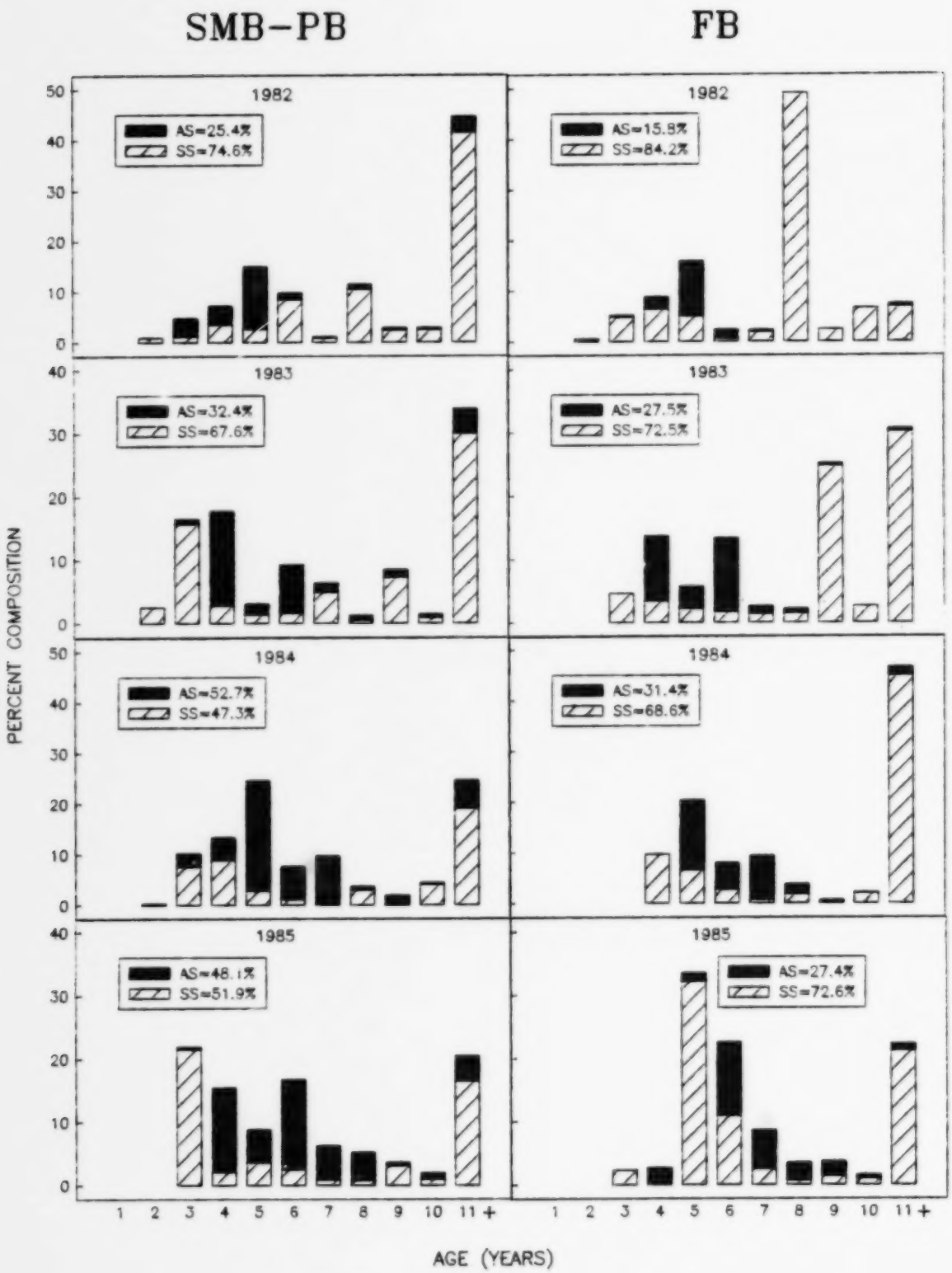


Fig.4. Age composition of herring from research gillnets, St. Mary's – Placentia Bays and Fortune Bay, 1982–85.

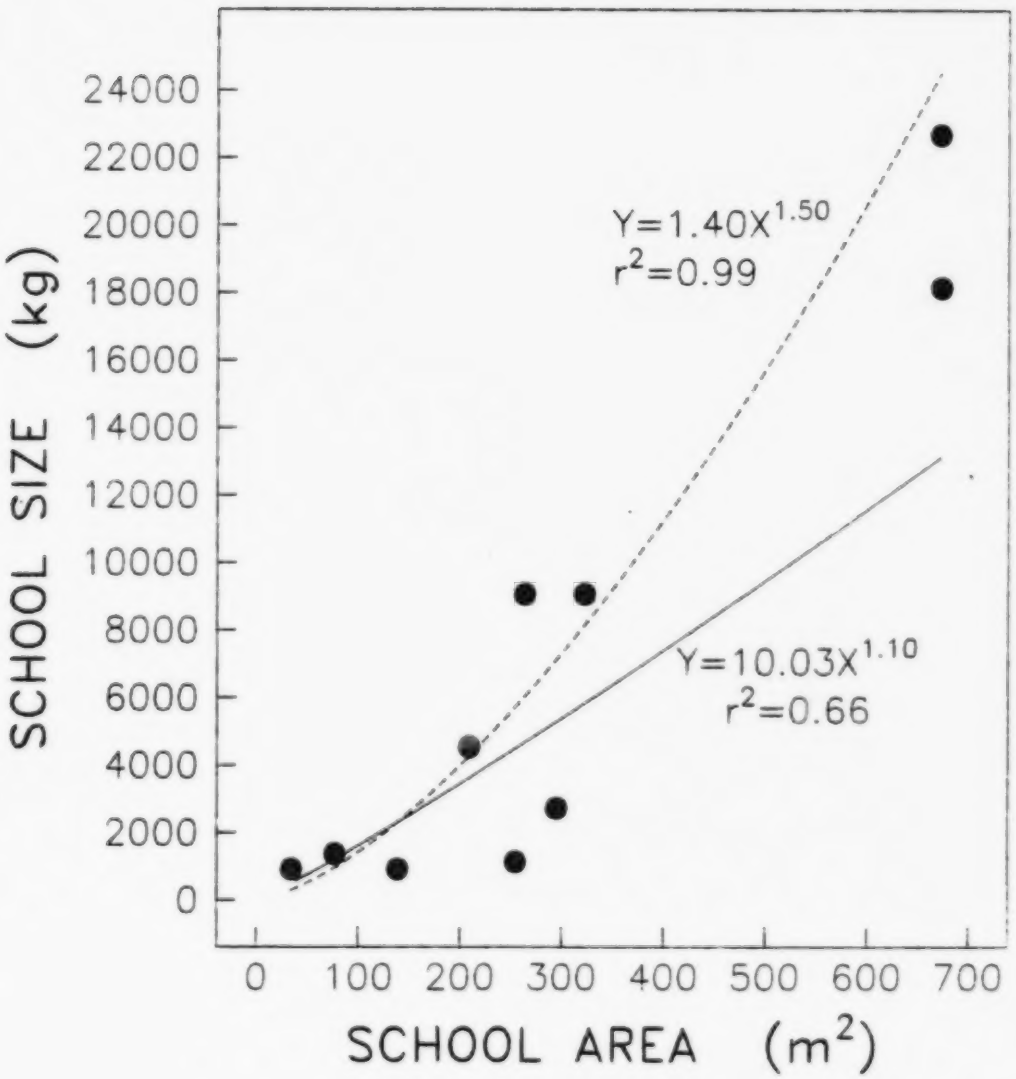


Fig.5. Relation between school area and school size.

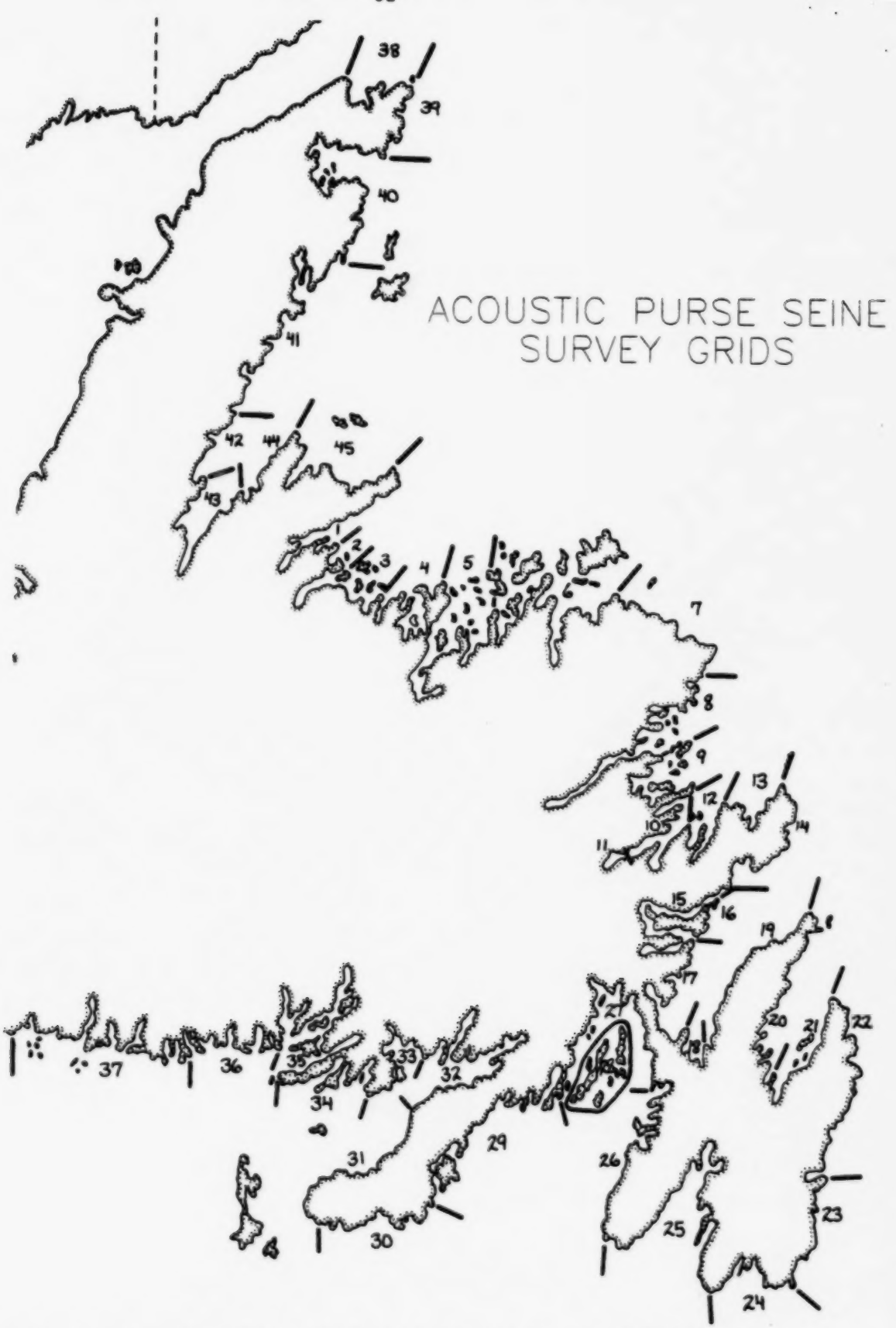
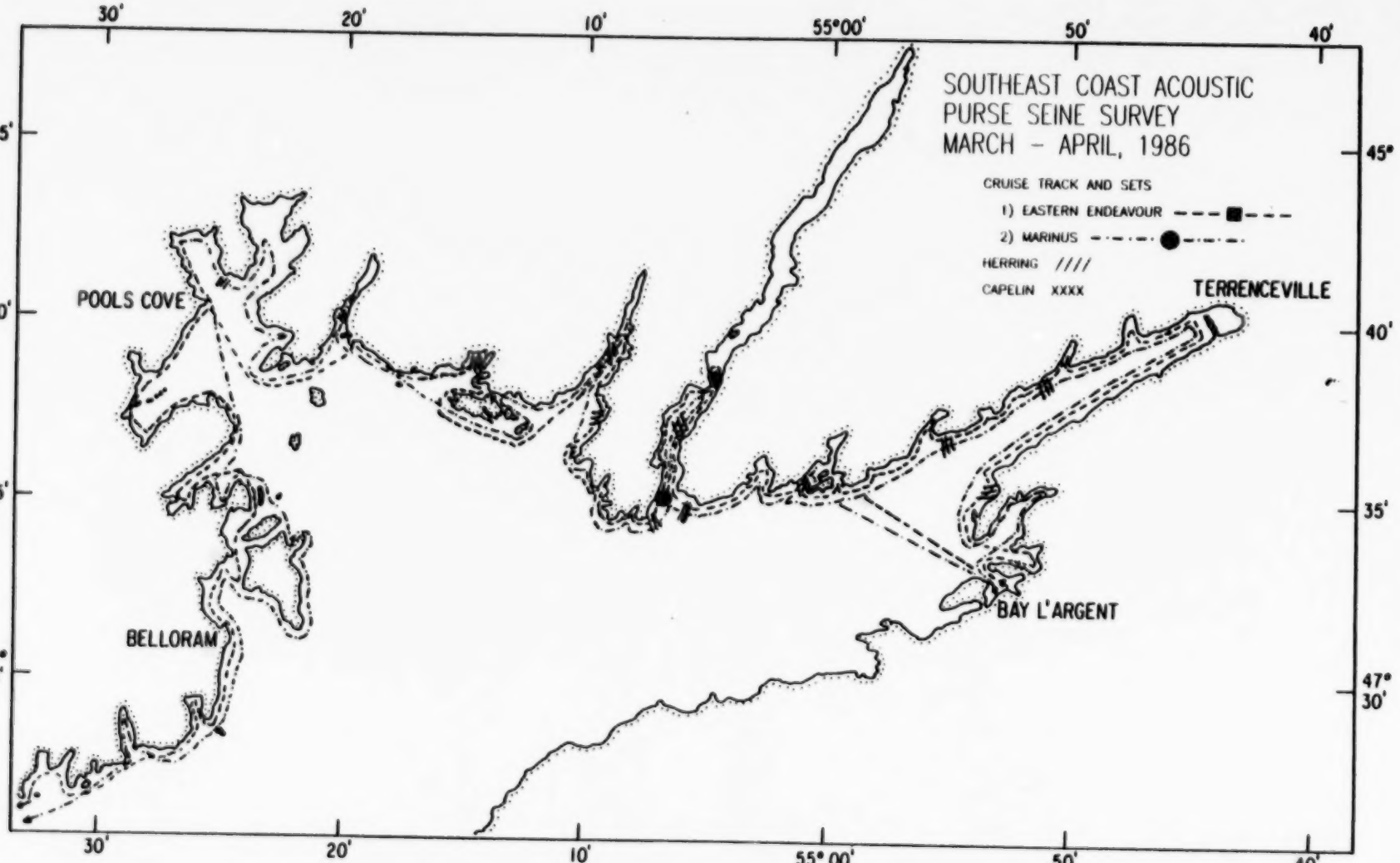
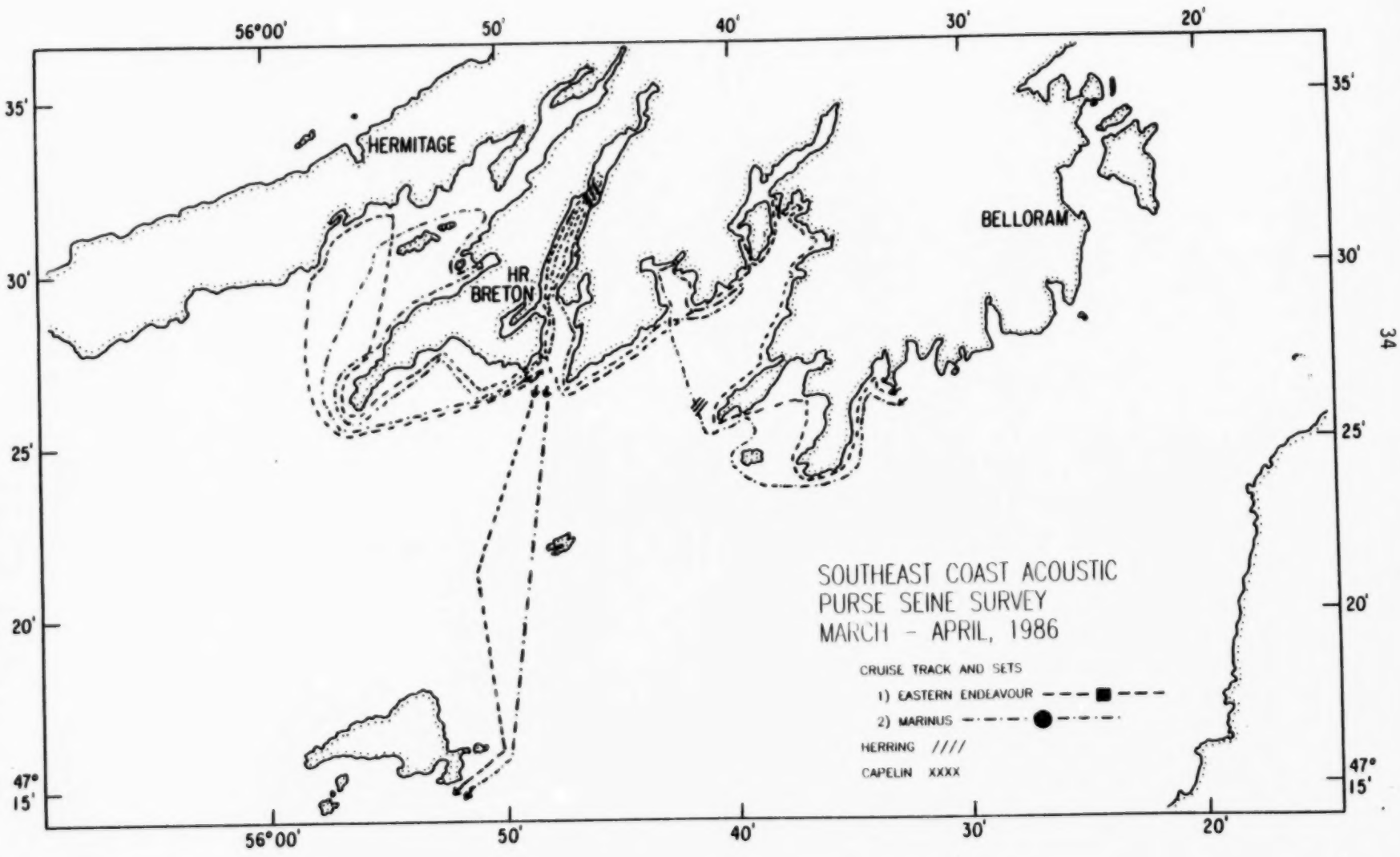


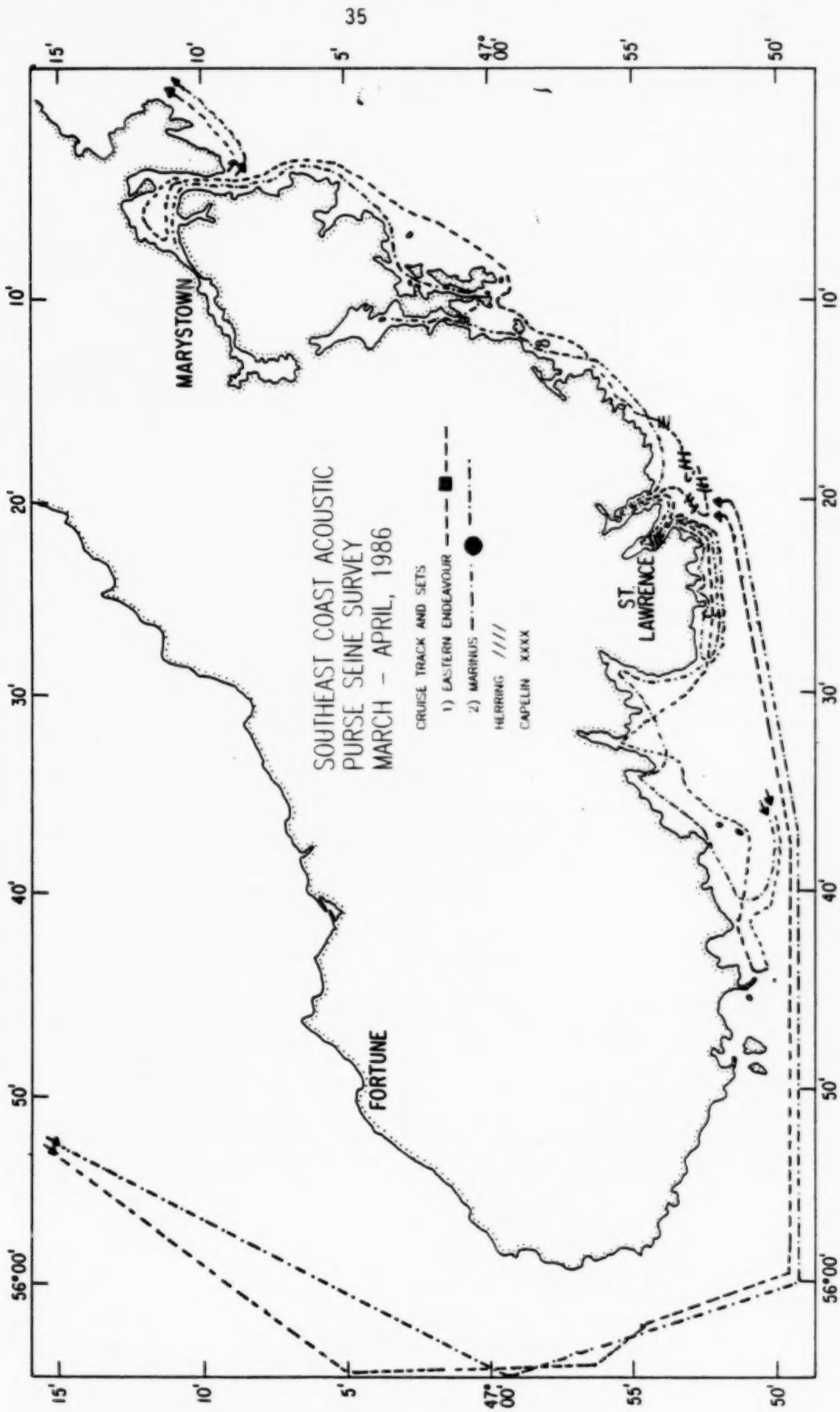
Fig. 6. Grids or subareas within each stock area used for the calculation of stock biomass from the acoustic purse seine survey.



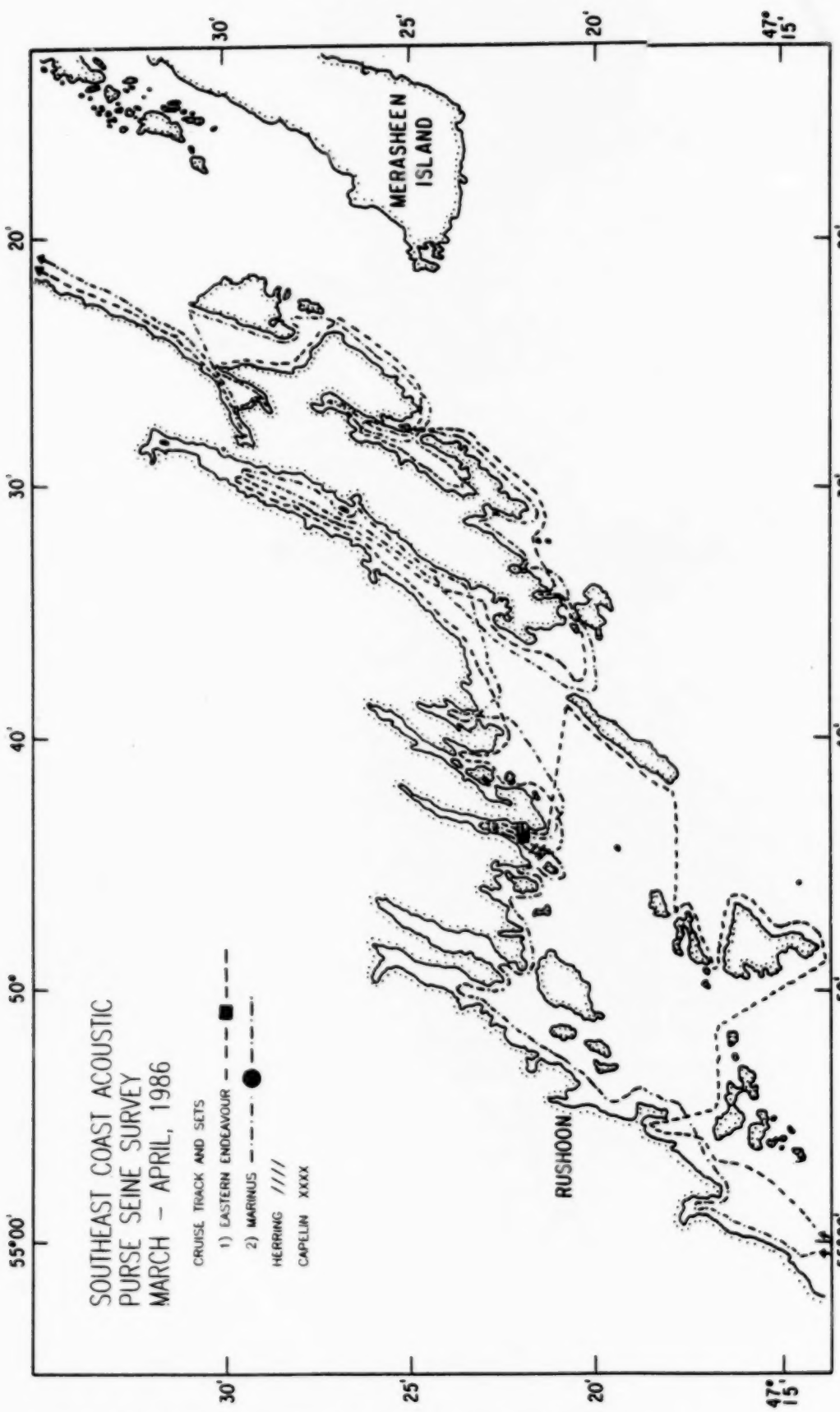
App. 1. Cruise track, herring markings, and set locations, acoustic purse seine survey, inner Fortune Bay, 1986.



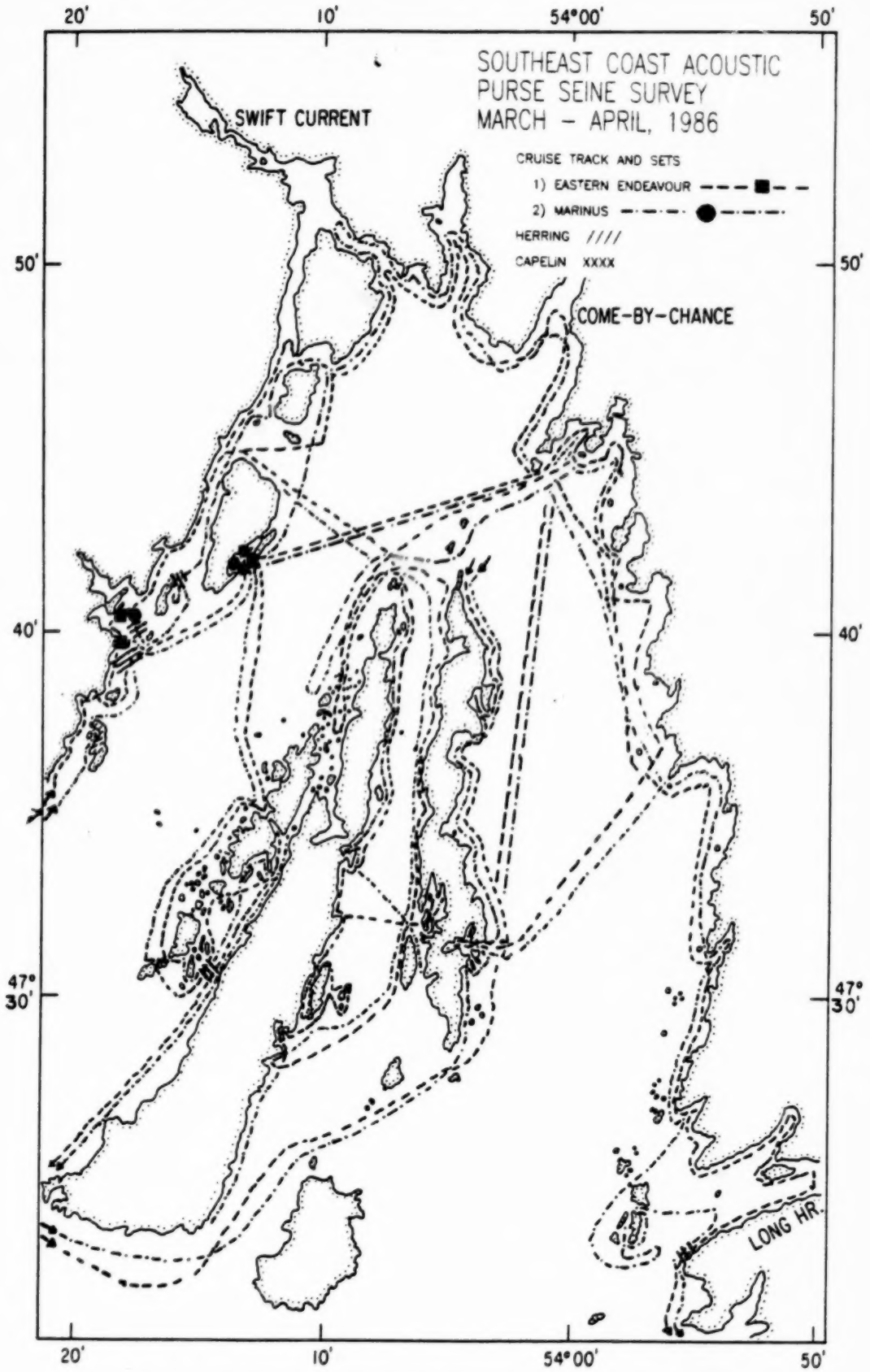
App. 2. Cruise track, herring markings, and set locations, acoustic purse seine survey, outer Fortune Bay, 1986.



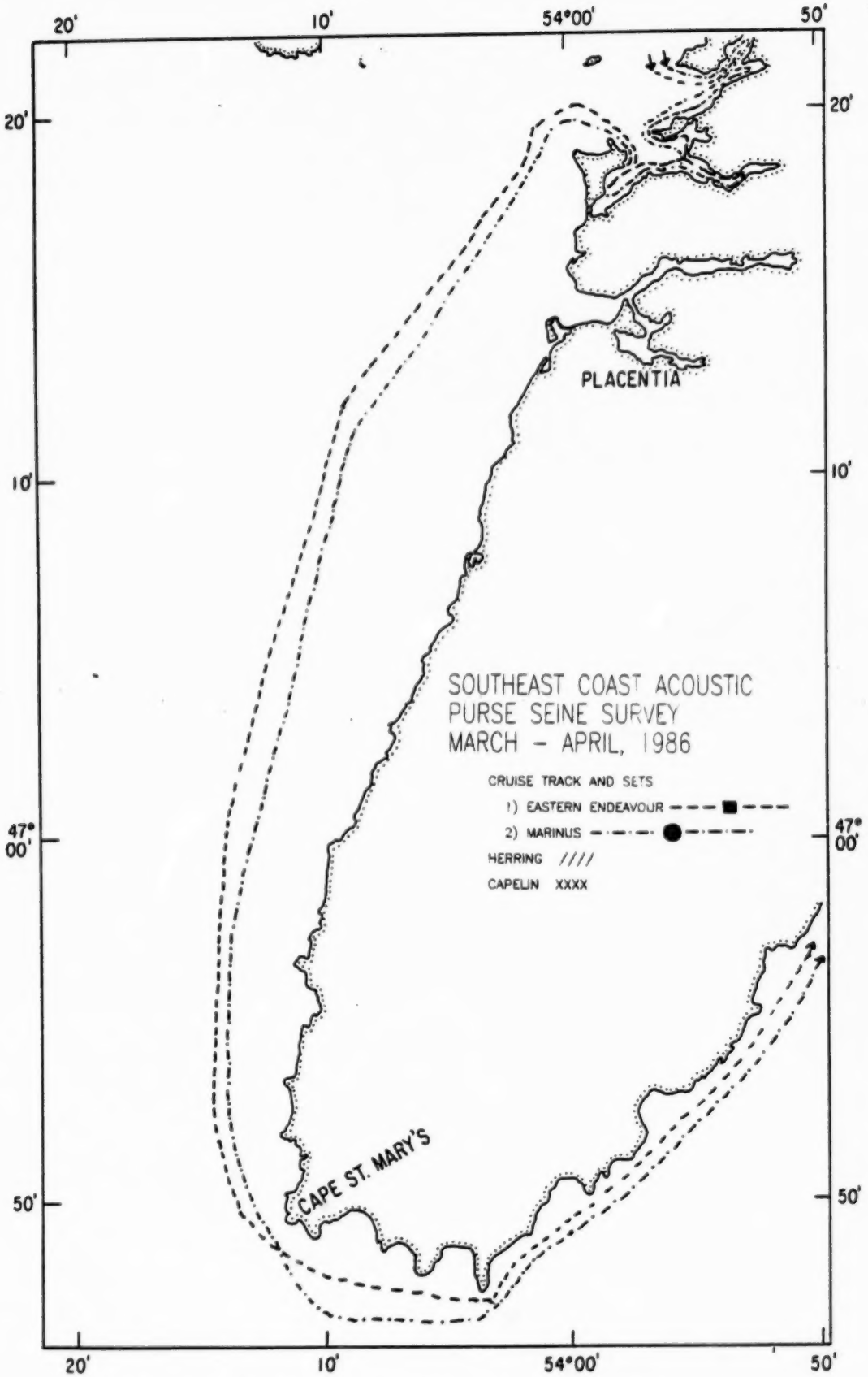
App. 3. Cruise track, herring markings, and set locations, acoustic purse seine survey, Fortune – Placentia Bays, 1986.



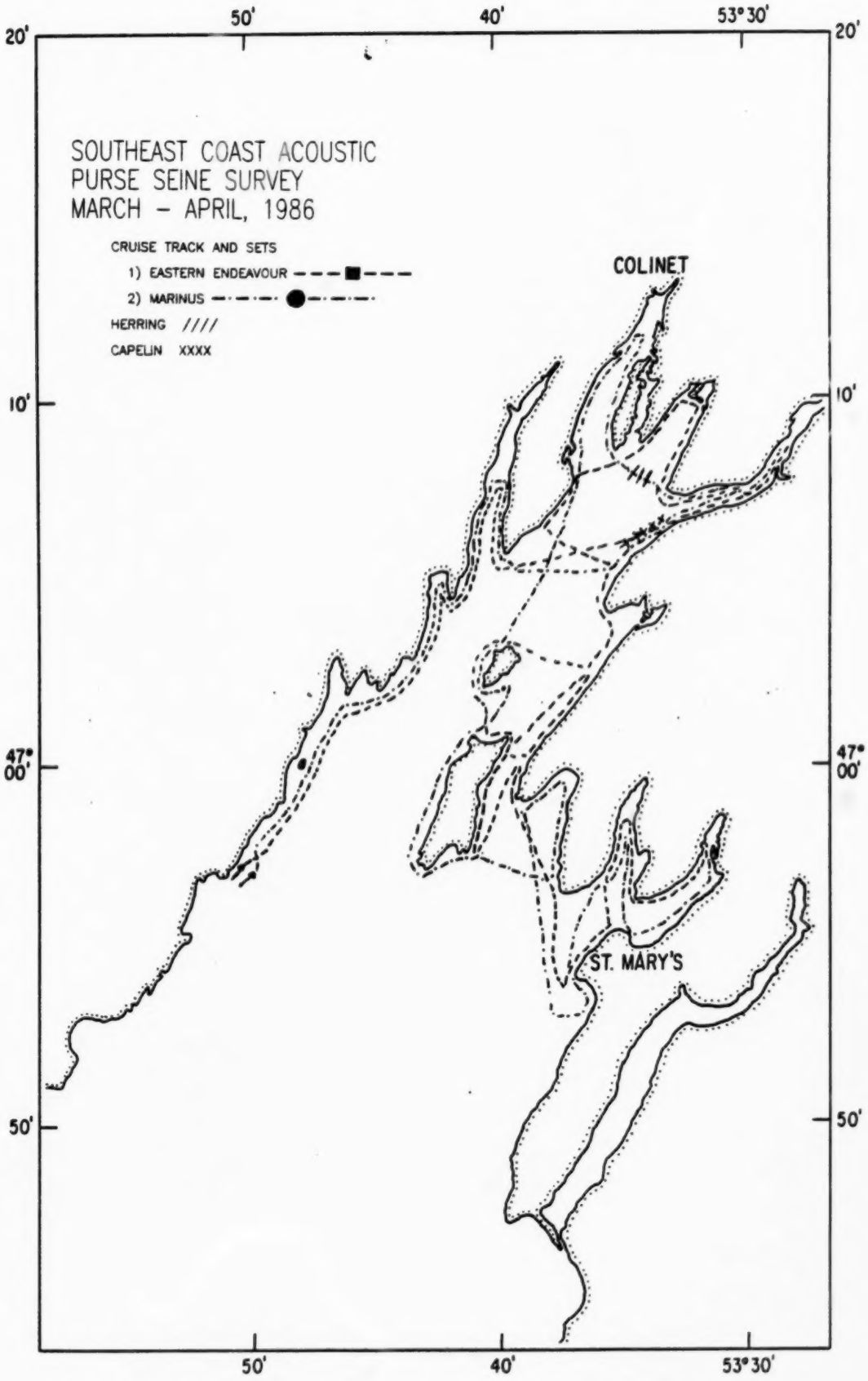
App. 4. Cruise track, herring markings, and set locations, acoustic purse seine survey, west side Placentia Bay, 1986.



App. 5. Cruise track, herring markings, and set locations, acoustic purse seine survey, inner Placentia Bay, 1986.



App. 6. Cruise track, herring markings, and set locations, acoustic purse seine survey, Placentia – St. Mary's Bays, 1986.



App. 7. Cruise track, herring markings, and set locations, acoustic purse seine survey, St. Mary's Bay, 1986.

Appendix 8. Purse seine set details, southeast coast acoustic survey, February-April 1986.

Set no.									
Eastern Endeavour	Marinus	Date	Time	Location	Surface temp. (°C)	Catch weight (kg)	Mean length (mm)	Sample no.	Comments
-	1	Feb. 28	1650	Long Harbor, Fortune Bay	-0.3	-	-	-	No catch
1	-	Mar. 4	1600	Long Harbor, Fortune Bay	0.2	-	-	-	5 herring meshed in foot
-	2	Mar. 22	0845	Western Cove, Placentia Bay	-0.9	-	-	-	No catch
-	3	Mar. 22	0932	Western Cove, Placentia Bay	-0.9	-	-	-	No catch
-	4	Mar. 22	1015	Western Cove, Placentia Bay	-0.9	-	-	-	No catch
2	-	Mar. 22	1245	Western Cove, Placentia Bay	-0.9	100,000	311	H1 & 2	75% 1982 year-class
-	5	Mar. 24	1745	Great Goat Island, Placentia Bay	-0.2	-	-	-	No catch
3	-	Mar. 24	1755	Great Goat Island, Placentia Bay	-0.2	-	-	-	No catch
4	-	Mar. 31	1650	Nan Point, Placentia Bay	0.7	300,000	311	H3, 4	75% 1982 year-class

Appendix 9. Herring tagging experiments, southeast coast acoustic survey, February-April 1986.

Date	Time	Location	No. tagged	Tag series	Comments
Mar. 22	1330	Western Cove, Placentia Bay	1000	30501D-31500D	75% 1982 year-class
Mar. 31	1720	Nan Point, Placentia Bay	1000	31501D-32500D	75% 1982 year-class

Appendix 10. Catch at age (numbers of herring) calculated from catch/effort data and biological samples for the research gillnet program, by area and season.

Area	Season	Age	Autumn spawners 1982	1983	1984	1985
SMB-PB	Spring	1	-	-	-	-
		2	-	-	-	-
		3	67	67	863	126
		4	68	1370	1508	4778
		5	234	150	7454	1854
		6	22	699	2232	5073
		7	4	132	3178	1886
		8	18	61	206	1585
		9	8	97	567	194
		10	5	45	112	320
		11+	58	349	1891	1413
		Total	484	2970	18010	17228
			Spring spawners			
			1982	1983	1984	1985
		1	-	-	-	-
		2	18	227	101	-
		3	23	1444	2589	7692
		4	66	256	3038	750
		5	49	126	962	1293
		6	162	147	372	903
		7	18	452	132	310
		8	200	50	1022	279
		9	46	669	34	1123
		10	48	82	1393	354
		1+	790	2747	6540	5902
		Total	1421	6200	16182	18607
			Combined			
			1982	1983	1984	1985
		1	-	-	-	-
		2	18	227	101	-
		3	90	1511	3452	7818
		4	134	1626	4546	5527
		5	282	276	8416	3148
		6	184	846	2604	5976
		7	21	584	3309	2196
		8	218	111	1228	1864
		9	54	766	601	1317
		10	54	127	1505	674
		11+	849	3096	8430	7315
		Total	1905	9170	34192	35835

Appendix 11. Catch at age (numbers of herring) calculated from catch/effort data and biological samples for the research gillnet program, by area and season.

Area	Season	Age	Autumn spawners 1982	1983	1984	1985
FB	Spring	1	-	-	-	-
		2	-	-	-	-
		3	2	-	-	8
		4	18	1082	-	833
		5	86	361	1595	476
		6	13	1236	608	4442
		7	2	122	1006	2324
		8	-	63	207	1051
		9	-	30	51	827
		10	-	-	12	197
		11+	4	39	177	351
		Total	126	2933	3658	10508

		Spring spawners 1982	1983	1984	1985
	1	-	-	-	-
	2	4	-	-	-
	3	38	495	-	870
	4	51	361	1130	153
	5	40	234	765	12321
	6	5	183	316	4179
	7	15	152	78	950
	8	392	159	208	274
	9	19	2642	19	522
	10	53	275	229	385
	11+	55	3219	5250	8139
	Total	672	7720	7996	27793

		Combined 1982	1983	1984	1985
	1	-	-	-	-
	2	4	-	-	-
	3	40	495	-	878
	4	70	1443	1130	986
	5	127	596	2360	12797
	6	17	1419	925	8621
	7	17	274	1084	3274
	8	392	222	415	1324
	9	19	2672	71	1349
	10	53	275	241	582
	11+	59	3257	5428	8490
	Total	798	10653	11654	38301